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AUTHOR Tamir, Pinchas; Amir, Ruth
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ABSTRACT

This study attempted to measure the functional availability of knowledge and skills acquired in high school biology as they affect the achievement of students in a first year university course. The study, referred to as retrospective curriculum evaluation, uses a self-assessment instrument, the Knowledge and Prior Study Inventory (KPSI). An analysis of the results is given with reference to their high school preparation in biology and interpreted with reference to Ausubel's learning theory. (Author/SA)

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Retrospective Curriculum Evaluation
An Approach to Evaluation of Long Term Effects

Pinchas Tamir & Ruth Amir
School of Education and
Israel Science Teaching Center
Hebrew University, Jerusalem

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Retrospective Curriculum Evaluation:

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Abstract

College students enrolled in a first year biology course were studied for their knowledge and skills prior to the course, their perceived difficulty and interest in different aspects of the course and their actual achievement in the course. The results were analyzed with reference to their high school preparation in biology. High school experiences were found to exert significant impact on the availability of knowledge and skills for further learning which, in turn, substantially affect the students achievement in the course. Interpretation of the results based on Ausubel's theory led to valuable conclusions regarding the kind of high school course which provides meaningful learning with long lasting effects.

Introduction

Curriculum evaluation may be defined as "the systematic collection, analysis, and interpretation of data that bear on the effectiveness, sufficiency, and efficiency of the program in meeting its goals or otherwise providing a public good in the absence of public harm" (Jaeger, 1978, p. 302). One of the major goals of the "new" science curricula of the 1960's was to teach the structure of the disciplines. Thus, for example, the major aim of the BSCS (Biological Science Curriculum Study) "is to present a valid image of current biological science... in terms of major dimensions (namely)...the subjects to be investigated, the major generalizations and conceptual schemes...and the modes of investigation" (Klinckman, 1970, p. 9). Bruner (1960) asserts that "grasping the structure of a subject is understanding in a way that permits many other things to be related to it" (p. 7). Furthermore, "it is indeed a fact that massive general transfer can be achieved by appropriate learning, even to the degree that learning properly under optimum conditions leads one to 'learn how to learn'" (ibid., p. 6). Cronbach (1963) supports this view as he writes:

> "Outcomes of instruction are multidimensional...the outcomes observed should include general outcomes ranging far beyond the content of the curriculum itself - attitudes, career choices, general understandings and intellectual powers, and aptitude for further learning in the field..."

It is the last outcome, namely the aptitude for further learning, which is the focus of the present study. The only way to study this outcome is to examine students who were exposed to particular learning experiences as they attempt to study new related learning materials. The ability of students to study such new learning materials following an extended interval between their prior and new

learning, may be regarded as an indicator of the long term effects of the prior learning. Hence, retrospective evaluation is a process by which one evaluates the merits of a particular instructional program in terms of its long term effects. The importance of retrospective evaluation is strongly supported by people like Ausubel, who seriously question the validity of results obtained in immediate final examination for assessing the worth of a curriculum, on the basis that "motivated students can learn for examination purposes large quantities of overly sophisticated and poorly presented material that they do not really understand" (Ausubel, 1968, p. 578). Some attempt to measure long term effects by retention tests. Usually such tests are administered several weeks after the completion of learning. Sometimes they are administered as much as a year later. Yet many delayed tests, when administered after longer periods of elapsed time, often fail to measure the potential of the precipitated knowledge in the cognitive structure, especially if they test for memorization of facts and details which are easy to forget (Tyler, 1930). Thus, many agree with Ausubel (1968, p. 577) that:

> "Perhaps the most valid way of testing for organizational strength and viability of knowledge is not to test retention in itself, or to use problem solving items, but to measure retention in the context of sequential learning - in situations where the ability to learn new material presupposes the availability of the old."

Ausubel (ibid.) suggests the use of a transfer retention test which requires students to study an unfamiliar new learning passage that is sequentially related to an presupposes knowledge of previously studied material. Such new passages have been used for the last 10 years as part of the matriculation examination in Israel (Dreyfus & Jungwirth, 1972; Tamir, 1978). Ausubel claims that such transfer retention tests "measure the functional availability of the previously learned material for new learning" (ibid.). Yet, it would seem that the best measure of

this functional availability is not the performance on a special transfer retention examination administered immediately after the completion of the course (as the matriculation examination mentioned above), but rather, performance in the context of learning a new course which is sequentially related to the previous one.

The present study attempts to measure the functional availability of knowledge and skills acquired in high school biology as they affect the achievement of students in a first year university biology course. The study is referred to as retrospective curriculum evaluation since the subjects are university students and the purpose is to evaluate the contribution of the high school curriculum to their performance at the university.

Retrospective studies have certain limitations. One limitation is the lack of control on events which have occurred in the interval between high school graduation and the college study period. In Israel this interval may be from two to four years due to compulsory military service following high school graduation. Another limitation is that the samples are by necessity selective, since they include only those students who continued their studies at the university.

On the other hand, retrospective studies may be justified on theoretical, methodological, and practical grounds. Theoretically, as Ausubel, Bruner, and Cronbach have suggested above, the measurement of retention and skills in the context of sequential learning may be the most valid way of testing. Methodologically, it is worth noting that the two alternative strategies for studying long term effects, namely, cross sectional and longitudinal followup have severe limitations (see, for example, Hilton & Patrick, 1970). Thus, in follow-up studies the same students are supposed to be followed up for several years and their achievements and/or attitudes are measured at different points in time. Yet, not only is it difficult and costly to locate the subjects, but it is often impossible to keep the original sample for a long period of time, hence attrition is a major handicap in such studies. Cross sectional studies are free of this handicap but

suffer from the fact that different students represent different stages of growth and one can never be sure of the magnitude of the effects of individual differences. On the other hand, retrospective evaluation, as will be demonstrated below, eliminates the constraints mentioned above since there is practically no attrition and the sample is fully maintained.

The practicality and usefulness of the retrospective approach have been empirically demonstrated in a study of the long term impact of discovery learning (Tamir & Goldminz, 1974). The present study offers additional support to the feasibility and practicality of conducting retrospective studies in an educational context.

Purpose of Study

The study attempts to evaluate the contribution of different high school programs to success in college biology by:

1. Assessing certain entry behaviors of a group of first year university students majoring in biology in relation to their high school background.
2. Assessing the achievement of these students in a first year general biology course, in relation to their high school background.
3. Relating the achievements of these students to their entry behaviors.
4. Assessing the perceived difficulties and interests of these students in different topics and components of the university biology course in relation to their high school background.

Method

Sample: The subjects were 116 biology majors enroled in a first year general biology course at the Hebrew University in the 1978-1979 academic year. High school students in Israel specialize in their last two years of high school in certain subject matter areas. 65% of the sample specialized in biology, 14% in

physics and math, and 10% in other areas, mainly humanities and social sciences. 11% were educated outside of Israel. 75% were females.

In 1965 the Israel BSCS Adaptation Program was introduced to a few high schools. In the 1970's, while our subjects were high school students, three different programs were operating in schools: the old traditional program, the new BSCS Adaptation, and a combination of both.

The old traditional program presented biology with a strong emphasis on memorization of facts mainly by verbal reception learning with strong emphasis on morphology and anatomy and relatively little emphasis on physiology, ecology, and investigative laboratory work. The new BSCS Adaptation followed the rationale and objectives of the BSCS in the United States with strong emphasis on biology as enquiry, on physiology and ecology, on the major themes of biology, and on investigative laboratory work. In several schools portions of the traditional course and some of the traditional textbooks were used in combination with portions of the new BSCS materials. The distribution of the subjects according to their high school program (self-reported) was as follows: Old (Traditional) 35%, New (BSCS) 47%, and Combination 18%.

Instruments: In addition to a background questionnaire which ascertained high school specialization and the nature of high school curriculum, the following instruments were used:

Knowledge and Prior Study Inventory (KPSI)

This inventory was designed according to a framework suggested by Tamir and first reported by Young and Tamir (1977). The inventory consists of a list of concepts or skills which is usually prepared by the course instructor as a means of either pretest or posttest or both. For each item (concept or skill), the students are asked to make two independent ratings, one for each of the scales:

1. Degree of knowledge scale. This is a 5 points scale in which

   1 = I don't know, don't understand, cannot do

   2 = I am not sure if I know, or understand, or can do

   3 = I think I know what it means, I think I can do

   4 = I know, I understand, can do well

   5 = I can explain, show how to do, do others

2. Prior study scale. This is a 2 points scale in which

   1 = I have not studied this

   2 = I have studied this

In the present study a list of 86 concepts and 15 skills was prepared by the three course instructors. This list included concepts and skills which were considered by these instructors to be important for this course. Based on examination of high school curricula, the concepts and skills were subdivided by the authors into two groups: those that students may be expected to acquire in high school (to be referred to as "high school") and those which are not taught in high school (to be referred to as "college"). Examples of concepts included in the high school list (N = 57) are: Basic structure of carbohydrates, fats, and proteins, PH, enzymes, mitosis, membrane, centriole, electron transport chain, negative feedback, aerobic, dendrite. Examples of college level concepts (N = 29) are: Polysomes, microfilaments, ions pump, procaryotic, enzymatic induction, structural gene, operon, chemostat, post-synoptic membrane, action potential, syncetium. Examples of high school level skills (N = 10) are: preparing a microscopic slide, using a microscope, using a beurete. Examples of college level skills (N = 5) are: measuring pH with a pH meter, using a calorimeter, using a centrifuge. This inventory was administered at a special orientation session two weeks before the first class meeting of the course, by the course instructors as part of the routine requirements of the course.

Achievement test

This was a 60 multiple choice items end-of-course final examination which had a Kuder-Richardson 20 reliability of 0.86. For the purpose of analysis it was divided into two subtests: one according to the part of the course where it was studied: 37 items were based on material studied in lectures

16 items were based on material studied in discussions

7 items were based on material studied in the laboratory.

The second division was according to topics (see Table 4).

Attitude inventory

This inventory consisted of a list of the course topics. The students were asked to indicate on a 5 points scale for each item: a) the perceived difficulty (1 = very easy; 2 = easy; 3= moderately difficult; 4 = difficult; 5 = very difficult; and b) the degree of interest (1 = not interesting; 2 = somewhat interesting; 3 = moderately interesting; 4 = interesting; 5 = very interesting).

The last two instruments were administered at the end of the course, in a special examination session scheduled by the Department of Biology. The responses to the Attitude Inventory were anonymous.

Data analysis

The data obtained by the different instruments were analyzed by computer programs yielding frequency distributions as well as mean scores, standard deviations and internal consistency indices (Kuder Richardson 20 for the achievement test and α Cronbach for the other inventories). It is realized that the knowledge and the attitude inventories are ordinal scales and the Prior Study inventory is a nominal scale. Therefore it was decided to report frequency counts of the results. At the same time, however, we report also mean scores and standard deviations in order to provide a rough and easy to grasp estimate of the results. Since both frequency counts and

means are reported the reader can make the necessary judgments using the two kinds of representations. Further analysis of the data involved the use of parametric statistics (Pearson correlations, analysis of variance and multiple regression analysis).

The decision to use parametric statistics for the categorical data obtained by the Prior Study scale is based on the assumption that "any dichotomy can be treated as though it were interval-level measure . . . since the requirement for distance measure based on equal sized intervals is also satisfied because there is only one interval naturally equal to itself" (Nie et al. 1975, p. 6).

The use of parametric statistics with the ordinal scales is based on Abelson and Tuckey (1959) and on Labovitz (1970) who argues that interval statistics can be applied to any ordinal level variable since "although some small error may accompany the treatment of ordinal variables as interval, this is offset by the use of more powerful, more sensitive, better developed, and more clearly interpretable statistics with known sample error".

Results

Entry behaviors

Table 1 presents the results of the KPSI.

Insert Table 1 about here

The differences between high school and college level items are very conspicuous regarding both prior knowledge and prior learning. It is not surprising to find that 90% of the subjects indicated that they did not know and did not understand the concepts classified at the college level. Somewhat smaller differences were found between high school and college level skills, but still twice as many students felt that they mastered high school level skills. The fact that 45% reported that they knew the high school concepts but only 22% were willing to rate themselves as 4 or 5 may be explained by the length of time (two to four years)

that elapsed between high school graduation and entrance to the university.

Table 2 shows relatively high correlations between prior knowledge and prior learning.

While a priori one may question the validity of self report assessments the results shown in Tables 1 and 2 offer some support to the validity of these self reports since both the differences between high school and college level items and the positive correlation between prior learning and prior knowledge are in the expected directions.

Insert Table 2 about here

While there were no statistically significant differences between the mean response ratings of male and female students, substantial influence of the nature of high school biology studies was found.

Insert Table 3 about here

Regardless of the nature of the curriculum studied students who specialized in high school biology reported significantly higher levels of prior learning and knowledge than other students.

As to the nature of the curriculum, students who had studied the new (BSCS) program reported substantially higher levels of prior learning and knowledge than those who had studied the old program. The combination group occupied a middle position. It may be concluded that upon their entrance to the university students who had specialized in biology and who studied the new high school biology curriculum appear to have, on the average, substantial superiority over others as far as relevant knowledge and skills are concerned.

Achievement

Will the advantage at the entry stage persist and be reflected in the actual achievement in the course? Table 4 presents the results in the final examination.

Insert Table 4 about here

It may be observed that while in general the results are quite high, substantial differences exist between different subtests. Most conspicuous is the relatively low achievement in items based on the laboratory (these include the whole of subtests Heart and circulatory system, as well as one item each in subtest Physiology and Cell life cycle). On the other hand, items based on topics which were the focus of group discussions had the highest mean scores. These results may be interpreted as implying that knowledge gained in the laboratory was not well consolidated, perhaps due to the absence of post laboratory discussion (see Tamir, 1977). The relatively high achievement in items based on group discussions support the view that consolidation of knowledge is best accomplished through discussions. Tables 5 and 6 show the effects of high school background on achievement.

Insert Tables 5 and 6 about here

It may be clearly observed that students who had specialized either in biology or in physics-mathematics in high school did not differ in their achievement in college biology, but both groups achieved significantly better than students who had specialized in humanities or in social science or who had studied abroad.

The results in Table 6 reveal a substantial and statistically significant difference between students who studied the old and the new (BSCS) program to the advantage of the last. Partially BSCS students occupied a middle position but their achievement was not statistically significantly different from the other two groups.

The similarity of these results to those obtained at the beginning of the course (See Table 3) is striking. It may be concluded that the superiority of biology specialization and the new BSCS program as far as achievement in col-

lege biology is concerned has been strongly supported. The results of Table 7 reveal low but consistently positive correlations between results of the KPS.I and end of course achievement. These results lend further support to the conclusion just stated and confirm earlier findings about the positive effect of prior knowledge on achievement (e.g. Ausubel, 1968; Bloom 1976, Novak et al. 1971).

Insert Table 7 about here

The relative contribution of different independent variables

The purpose of the study is to find out not only whether or not background variables affect further learning but also their relative contribution to various achievement measures. Two analyses were performed to reach this end. First the students were divided into four groups in order to find out the combined effect of specialization and curriculum in high school. Table 8 presents the comparison of the four groups in their prior learning, prior knowledge and achievement.

Insert Table 8 about here

It may be observed that students who studied the BSCS curriculum and specialized in biology had on the average an advantage over all other groups. Students who had specialized in biology but had not followed the BSCS curriculum were, in many respects, similar to BSCS students who had not specialized in biology. The small group (N=7) of non-BSCS students who had not specialized in biology were especially talented students who had specialized in physics-math in high school, and were able to compensate for their deficient preparation in biology by utilizing their talents in their college studies. It may be concluded that the combination of BSCS curriculum and specialization in high school biology offers the best preparation for college biology.

What is the relative contribution of each backgroundvariable? Table 9 presents the results of stepwise multiple regression analysis.

Insert Table 9 about here

The results show very clearly that all the background variables included account for 22% of the variance in total achievement. Of these, the curriculum accounts for half, namely 11%, and high school specialization for less than 8%. Most of the variance is accounted for by three variables, namely high school curriculum, possession of college laboratory skills and extent of learning high school concepts. Although each of the rest of the simple correlations is statistically significant, unsurprisingly substantial overlapping exists among many of the independent variables.

Examination of the subtest results shows that value regarding achievement in lecture items, high school curriculum accounted for 13% of the variance, with regard to discussion items it accounted for 5%, and with regard to the 7 laboratory items it accounted only for less than 3%. High school specialization accounted for about 5% in each of the subtests. The results show that the contribution of prior knowledge and high school background may be different for different parts of the college course.

Perceived difficulty and interest

The attitude questionnaire was administered anonymously so it was impossible to correlate its results with that of the other instruments. Nevertheless, the results reveal low positive correlation between interest and perceived difficulty.

Insert Table 10 about here

It may be seen that topics rated as easy tend to be conceived as less interesting. This is especially relevant to laboratory work in which routine, cookbook activities usually do not challenge the students and are therefore conceived as less interesting. It is worth noting that although the laboratory was, on the average, conceived as least difficult, the results of the final examination reveal lowest mean score in subtest laboratory (See Table 4).

Students who had specialized in high school biology had consistently less difficulty in coping with the demands of the college course. The mean perceived difficulty of the total final examination, on a 5 point scale was 3.36 (S.D.=.41) and 3.55 (S.D.=.46) for the students who had specialized in high school biology (N=63) and those who had not specialized in high school biology (N=33) respectively ($t=2.10$, $p<0.05$). These results offer additional independent support to the advantage of specializing in high school biology.

Discussion

The present study made use of a relatively novel instrument, KPSI, which relies on students' self-assessment. The validity of KPSI was ascertained in several previous studies (e.g. Young and Tamir, 1977). The results of the present study offer strong support to its validity in two ways: First, a substantial differences was obtained between the mean scores of high school and college items in the expected direction. Second, there exists a relatively high correlation between knowledge and prior study scores, again a result which could have been expected. Lastly, the positive correlations between knowledge as measured by KPSI prior to the course and the post test achievement scores may be also regarded as support for the KPSI validity. As many teachers and researchers know, pretests are often met with resistance by students and sometimes even by teachers who are reluctant to start their courses with such an irritating experience. KPSI has been found to be a convenient, economical, non-threatening device which was well accepted by both students and teachers.

In a previous study (Tamir et al., 1980), with a different sample of college students at the same university, the opinions of students on their high school biology were investigated. In that study it was found that:

1. On the average, high school experience was conceived to be more helpful in lectures than in labs.
2. Most valued was the help of prior biological knowledge to the understanding and retention of new material presented in lectures.

3. Students who specialized in high school biology as well as those who studied the "new" inquiry oriented curriculum had considerable advantage over others in understanding and learning from lectures.
4. With regard to the study in university laboratories the most helpful experience was that of students who studied the "new" curriculum in an academic high school, specializing in biology and spending at least two hours per week doing inquiry oriented laboratories.
5. Students who had had more inquiry oriented experiences in high school had higher level of expectations from their university studies.

The findings stated above are in full agreement with those of the present study. However, there is considerable difference between the two retrospective studies. The study of Tamir et al. (1980), like most retrospective studies, required the students to recall the experiences of the past. One may argue that such recall data can be unreliable. However, in the present study, in which the purpose was to measure aptitude for further learning, this restriction does not apply. Background data such as high school specialization and high school curriculum were gathered accurately and the dependent variables directly related to the present status of the sample. The design of the study is strengthened by the use of three dependent variables, each measuring differently the capacity for further learning. Thus the KPSI in itself is a measure of retention and possession of knowledge or skills which were identified as important and relevant to the study of college biology by the instructors of the college course. The attitude questionnaire is an expression of perceived difficulty of different topics by the students which is, at least partially, reflection of their prior knowledge. Lastly, the college course achievement scores are a direct measure of further learning in a real life situation, in which the measures of achievement were not designated just for the purpose of the study by the researcher, but were, rather, the tests used in the course which actually determined the students standing in the university.

Bearing in mind the limitations of the present study and especially the

selectivity of the sample which restricts the generalizability to similar students, the following conclusions may be offered:

1. KPSI is a valid and reliable measure of prior learning and prior knowledge of concepts and skills.
2. What students learn in high school makes significant impact on the learners. Students who elect to major in college biology are able to recall many of the topics and skills they learned in high school.
3. Knowledge at the entry to the university is positively correlated with the extent and nature of the learning of biology in high school.
4. Achievement in college biology is significantly correlated to prior knowledge of concepts and skills.
5. Achievement in college biology is significantly correlated to the nature of the high school biology curriculum.
6. Specializing in high school biology and studying an inquiry oriented curriculum such as the Israel BSCS Adaptation, results in substantial advantages for the study of college biology. These advantages are reflected by the perceived difficulty of the college biology course and most importantly by the achievement in that course.
7. The contribution of high school experiences is especially evident in the learning and achievement related to concepts studied in lectures (which comprised the larger portion of the particular college course studied).
8. The results offer direct support to Ausubel's (1968) theoretical notions about the relationship between prior learning and subsequent achievement.
9. The results indicate that the new high school biology in Israel creates the conditions for meaningful learning which exerts lasting long term effects at least on those students who continue their studies in college.
10. Retrospective evaluation, built on sound theoretical ground, may yield significant results on long term effects of curricula and educational experiences and add an important dimension to the field of curriculum evaluation.

References

Abelson, R. P. and Tuckey, J. W. Efficient conversion of non-metric information into metric information in E. R. Tufte (Ed.) The Quantitative Analysis of Social Problems, Reading, Mass. Addison Wesley, 1970, pp. 407-417.

Ausubel, D. P. Educational Psychology - A Cognitive View, Holt, Rinehart & Winston, New York, 1968.

Bloom, B. S. Human Characteristics and School Learning, McGraw Hill, New York, 1976.

Bruner, J. S. The Process of Education, Vintage, New York, 1960.

Cronbach, L. J. Course improvement through evaluation, Teachers College Record, 1963, 64, 672-683.

Dreyfus, A. and Jungwirth, E. The Israeli Bagrut Examination, Journal of Research in Science Teaching, 1972, 9, 361-368.

Hilton, T. L. and Patrick, C. Cross sectional versus longitudinal data: an empirical comparison of mean differences in academic growth. Journal of Educational Measurement, 1970, 7, 15-24.

Jaeger, R. M. About educational indicators: statistics on the conditions and trends in education, in L. S. Shulman (Ed.) Review of Research in Education, 1978, 6, 276-315.

Klinckman, E. Biology Teachers' Handbook, Wiley, New York, 1970.

Labovitz, S. The assignment of numbers to rank order categories, American Sociological Review, 1970, 35, 515-524.

Nie, N. H. et al. Statistical Package for the Social Sciences, Second Edition, New York, McGraw-Hill, 1975.

Novak, J. D., Ring, D., and Tamir, P. Interpretation of research findings in terms of Ausubel's theory and implications for science education. Science Education, 1971, 56, 483-526.

Tamir, P. How are the laboratories used? Journal of Research in Science Teaching, 1977, 14, 311-316.

Tamir, P. The potential role of examinations in innovative curricula, The American Biology Teacher, 1978, 40, 353-357.

Tamir, P. and Goldminz, E. Discovery learning as viewed in retrospect by the learners. Journal of College Science Teaching, 1974, 4, 23-26.

Tamir, P., Amir, R., and Nussinovitz, R. High School preparation for college biology in Israel. Higher Education, 1980, 9, in press.

Tyler, R. What high school pupils forget. Educational Research Bulletin, 1930, 9, 490-492.

Young, D. B. and Tamir, P. Identifying what students know. The Science Teacher, 1977, 44, 27-28.

Table 1: Distribution of responses regarding knowledge and prior study (N = 116)

Concept or skill		Number of items	Knowledge				Prior Study		
			Distribution of counts (in percents)				Learned (in percents)		
			1 + 2	4 + 5	$\bar{x}$	S.D.		$\bar{x}$	S.D.
Concepts	High school level	57	35	22	2.92	.71	72	1.72	.23
	College level	29	90	2	1.77	.58	36	1.36	.23
Skills	High school level	10	28	38	3.10	.92	76	1.76	.24
	College level	55	49	16	2.54	.88	54	1.54	.30

Knowledge response scale: 1 = don't know; 3 = not sure; 5 = can explain to others.

Prior study scale: 1 = did not study ; 2 = studied

Internal consistency coefficients (Cronbach α) were above 0.9 for concepts and above 0.8 for skills.

Table 2: Intercorrelations* between levels of prior study and knowledge

(N=114)

Prior study		Knowledge: High school concepts	Knowledge: High school skills	Knowledge: College concepts	Knowledge: College skills
High school	concepts	.63	.45	.39	.45
	skills	.65	.59	.24	.50
College	concepts	.44	.35	.55	.40
	skills	.72	.42	.30	.61

*Pearson correlations were calculated

All values are significant beyond 0.01

Table 3: Mean response levels of groups with different high school backgrounds

		Concept or skill	Specialization in high school: Biology N=70 $\bar{x}$	S.D.	Physics Math N=15 $\bar{x}$	S.D.	Humanities N=6 $\bar{x}$	S.D.	Other N=5 $\bar{x}$	S.D.	Abroad N=12 $\bar{x}$	S.D.	F	High school curriculum: New N=54 $\bar{x}$	S.D.	Combination N=20 $\bar{x}$	S.D.	Old N=40 $\bar{x}$	S.D.	F
High school	Concepts	Knowledge	3.2	.6	2.2	.4	2.0	1.1	2.1	.8	2.4	.9	9.7**	3.1	.7	3.0	.5	2.4	.8	14.1
		Prior study	1.8	.3	1.4	.2	1.5	.3	1.6	.2	1.5	.5	5.4**	1.8	.2	1.7	.2	1.5	.4	14.1
	Skills	Capability	3.2	1.0	2.8	1.0	2.0	1.5	2.4	.9	2.3	1.2	3.0*	3.4	.7	3.0	1.2	2.5	1.1	11.2
		Prior study	1.8	.4	1.6	.2	1.4	.2	1.6	.3	1.3	.2	3.1*	1.8	.2	1.6	.6	1.5	.5	11.2
College	Concepts	Knowledge	1.8	.5	1.2	.2	1.2	.6	1.1	.4	1.7	1.1	4.4**	1.8	.5	1.7	.4	1.4	.7	3.9
		Prior study	1.4	.2	1.1	.1	1.2	.2	1.2	.2	1.2	.4	3.5*	1.4	.2	1.3	.2	1.2	.3	6.0
	Skills	Capability	2.6	.9	2.3	1.2	1.4	.9	2.2	.8	2.0	1.0	2.1*	2.9	.8	2.1	1.0	2.0	1.0	12.5
		Prior study	1.5	.4	1.3	.3	1.3	.3	1.4	.2	1.2	.6	1.7	1.6	.3	1.4	.5	1.3	.5	4.0

Knowledge response scale: 1 = don't know; 5 = can explain to others.

Prior study scale: 1 = did not study 2 = studied

* $p < 0.05$ ** $p < 0.01$

Table 4: Mean achievement in the final examination and its subtests (N=105)

Subtest	No.of items	Mean	S.D.	percentage mean score
Lecture	37	27.61	5.24	74.6
Discussion group	16	12.98	2.31	81.1
Lab	7	3.10	1.23	44.2
Cell	18	13.46	2.74	74.8
Regulation	9	6.74	1.89	74.9
Microorganisms	10	7.41	1.79	74.1
Membrane	1	0.88	.33	87.9
R.N.A.	5	4.31	.83	86.1
Cell life cycle	4	3.44	.92	85.9
Physiology	3	2.00	.84	66.7
Genetics	4	2.93	1.05	73.2
Haemoglobin	1	0.95	.22	95.2
Circulatory system	1	0.33	.47	33.1
Heart	4	1.25	.79	31.3
Total	60	43.69	7.69	72.8

Reliability coefficient (Kuder Richardson 20) = 0.86

Table 5: Achievement in college biology according to high school specialization

Achievement measure	High school specialization 1. Biology N=72 $\bar{x}$	S.D.	2. Mathematics Physics N=12 $\bar{x}$	S.D.	3. Other N=20 $\bar{x}$	S.D.	F d.f.= 2,102	Duncan multiple range test 1:2	1:3	2:3
Final examination grade	45.67	6.32	46.23	4.90	40.25	8.18	5.73**		*	*
Lecture subtest	28.83	4.36	29.23	3.79	25.55	5.16	4.59**		*	*
Discussion	13.49	1.90	13.77	1.30	12.1	2.94	3.92*		*	*
Laboratory subtest	3.35	1.15	3.23	1.30	2.6	1.19	3.16*		*	
Microorganisms	7.76	1.50	7.92	1.71	6.4	1.88	6.16**		*	*
Genetics	3.10	.84	3.38	.87	2,45	1.36	4.67*		*	*
Heart	1.46	.75	1.38	.77	0.80	.70	6.21**		*	*
Final course grade	71.21	14.90	74.84	10.22	61.10	15.92	4.64**		*	*

* $p < 0.05$; ** $p < 0.01$

Table 6: Achievement in college biology according to high school curriculum

Achievement measure	Non - BSCS N=36		Partly BSCS N=17		B.S.C.S. N=51		F d.f.= 2,101	Duncan multiple range test 1:2	1:3	2:3
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.				
Final examination grade	42.28	7.52	45.23	6.06	46.61	5.61	4.86**		*	
Lecture subtest	26.78	4.63	27.94	4.51	29.71	3.79	5.22**		*	
Discussion group	12.58	2.61	13.82	1.51	13.59	1.84	3.11*			
Regulation	6.56	1.58	6.88	1.54	7.37	1.54	3.00*		*	
Microorganisms	6.97	1.70	7.64	1.22	8.00	1.43	4.98**		*	
Cell life cycle	3.25	1.10	3.59	.71	3.69	.58	3.06*		*	
Haemoglobin	.92	.28	1.00	--	1.00	--	3.00*		*	
Final course grade	64.6	16.46	71.00	13.21	73.5	13.34	4.05*		*	

* $p < 0.05$ ** $p < 0.01$

Table 7 : Correlation of course achievement and prior background

(N=105)

Achievement measure	Prior Background							
	Concepts				Skills			
	knowledge		prior study		knowledge		prior study	
	high school	college	high school	college	high school	college	high school	college
Final course grade	.15	.17	.29	.21	.22	.30	.31	.22
Final examination grade	.24	.24	.34	.24	.28	.36	.32	.26
Lecture subtest	.19	.17	.29	.19	.24	.30	.28	.21
Discussion group subtest	.22	.28	.32	.23	.22	.28	.27	.22
Lab subtest	.24	.23	.25	.26	.27	.37	.26	.29

$r = .16$ $p < 0.05$; $r = .23$ $p < 0.01$

Table 8: Prior study, prior knowledge and achievement of university students according to their high curriculum and specialization

Measure	1 Non-BSCS		2		3 BSCS		4		F	Duncan Multiple Range					
	Non-biology specialization (N=7)		Biology specialization (N=13)		Non-biology specialization (N=23)		Biology specialization (N=46)		*df=3,86*	1:2	1:3	1:4	2:3	2:4	3:4
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.							
High school concepts															
Knowledge	108.86	18.00	164.00	25.65	132.00	51.50	182.89	36.02	13.55**	*		*	*		*
prior study	74.00	10.88	93.31	25.94	86.04	21.05	104.02	7.00	11.88**	*	*		*		*
College concepts															
Knowledge	32.57	4.43	46.62	11.83	42.52	25.52	53.34	14.12	4.17*		*		*		*
prior study	31.14	3.39	36.00	8.81	35.56	8.67	40.04	6.43	4.40*				*		*
High school skills															
Knowledge	19.57	4.99	28.08	7.11	24.48	11.99	34.20	7.43	10.22**		*		*		*
prior study	13.57	.98	15.85	5.27	14.26	5.15	18.85	1.25	12.14**		*		*		*
College skills															
Knowledge	6.29	2,56	11.62	3.86	10.56	5.42	14.11	3.82	8.90**	*			*	*	*
prior study	5.29	.49	7.54	1.81	6,52	2.54	8.09	1.40	7.44**	*			*		*
Final examination grade	46.29	5.22	42.00	7 36	41.26	8.07	46.80	5.71	4.48*					*	*
Lecture subtest	29.71	3.86	26.38	4.77	26.22	5.11	29.76	3.93	4.50*					*	*
Discussion subtest	13.71	1.25	12.38	2.33	12,39	2.87	13.67	1.78	2.54						
Lab subtest	3.23	1,01	2.86	1.21	2.65	1.23	3.37	1.16	2.10						*
Final course grade	74.71	9.96	62.85	17.74	63.56	16.27	73.56	13.72	3.54*						

* $p < 0.05$; ** $p < 0.01$

Table 9: Stepwise multiple regression analysis with high school curriculum entered first (N=105)

Dependent var.	Total final examination				Lecture subtest				Discussion subtest				Lab subtest			
Independent var.	Var*	Simple R	Multiple R	R square	Var*	Simple R	Multiple R	R square	Var*	Simple R	Multiple R	R square	Var*	Simple R	Multiple R	R square
1 High school curriculum	1	.336	.336	.113	1	.355	.355	.126	1	.221	.221	.049	1	.160	.160	.026
2 College skills	2	.355	.403	.163	2	.304	.388	.150	3	.317	.329	.108	2	.369	.370	.137
3 Studied high school concepts	3	.338	.435	.189	3	.291	.403	.163	2	.275	.359	.129	9	.259	.406	.165
4 High school concepts	4	.240	.441	.194	4	.190	.414	.171	7	.279	.369	.136	5	.232	.432	.187
5 High school specialization	5	.278	.450	.203	6	.210	.424	.180	4	.272	.382	.146	7	.226	.439	.193
6 Studied college skills	6	.261	.462	.214	5	.250	.433	.188	5	.223	.394	.155	3	.270	.442	.195
7 College concepts	7	.243	.466	.218	8	.283	.435	.189	6	.218	.401	.161	6	.247	.443	.197
8 Studied high school skills	8	.320	.468	.219	7	.173	.436	.190	9	.230	.406	.165	8	.292	.444	.197
9 Studied college concepts	9	.243	.468	.219	9	.187	.437	.191	8	.267	.408	.166	4	.262	.445	.198

* The numbers under Var. correspond to the variable names in the left column. The variables are listed in the order of their entrance.

Table 10: Percieved interest and difficulty and their correlations in different areas

(N = 97)

Subtest	Interest		Difficulty		Correlation between interest and difficulty
	X	S.D	X	S.D	
Lecture	3.62	.69	3.09	.64	.26
Discussion group	3.84	.84	2.95	.81	.26
Lab	3.23	.82	2.39	.71	.31
Cell biology	3.66	.76	3.24	.73	.23
Regulation	4.21	.83	3.18	.77	.08
Bacteriology	2.96	1.05	2.76	.88	.13

r = .16, $p < 0.05$; r = .23, $p < 0.01$